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HEXCEL PRODUCTS INC.
2332 Fourth Street
Berkeley 10, California

DEVELOPMENT AND EVALUATION

OF A

LIGHTWEIGHT ALUMINUM HONEYCOMB CASE

Prepared Under
PICATINNY ARSNEAL
CONTRACT NO. DA-04-200-AMC-477(A)

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PROGRESS REPORT #3
R&D 6065
HEXCEL RESEARCH
ADVANCED STRUCTURES GROUP

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FOREWORD

This report has been prepared by the Research Division, Advanced Structures Group, Hexcel Products, Inc., Berkeley 10, California, under Picatinny Arsenal Contract No. DA-04-200-AMC-477(A), Hexcel Project No. 6065 - "Development and Evaluation of a Lightweight Aluminum Honeycomb Case". The report covers work accomplished during the month of March, 1964.

1. SUMMARY

1.1 During the current reporting period, work was done in the following areas: test equipment calibration, fabrication of tooling and test equipment, preliminary engineering drawing release, fabrication and testing of typical construction specimens, fabrication of the prototype Case HXL-1-477, and hydrostatic and drop testing of the prototype Case.

1.2 Tests were conducted on small specimens of typical construction using 1.2 lb/cu.ft. density core to simulate energy absorption cylinder and end caps. The test results showed agreement with the theoretical deceleration calculations given in Appendix B of Progress Report #2.

1.3 Test procedures and check lists have been completed for all tests except the Salt Spray, Sand and Dust, and Fragmentation Tests.

1.4 A revised Test Plan is included in this report (See Table 1). The only change involves reversal of the tests on Cases HXL-2-477 and HXL-3-477; that is, the tests originally scheduled to be performed on HXL-2-477 will be performed on HXL-3-477 and vice versa. The reason for the change is to postpone the temperature-shock, humidity, and vibration testing until the design modifications, necessitated by the results of the drop tests on HXL-1-477 have been proven by testing HXL-2-477.

1.5 Hydrostatic and drop tests were conducted on the prototype Case HXL-1-477. The hydrostatic test resulted in leakage in the energy absorption core. The drop tests resulted in high peak levels caused primarily by rigidity of the edge potting and the skins.

2. TESTING OF TYPICAL CONSTRUCTION

2.1 PURPOSE

The Predevelopment Study, reported in Paragraph 2 of Progress Report #2, showed that the core chosen for the hydrostatic cylinder is adequate, but that the core chosen for the energy absorption cylinder and end caps is too dense. Therefore, a core of 1.2 lb/cu.ft. density was chosen for energy absorption purposes. To assure the validity of the prototype design using 1.2 lb/cu.ft. core, typical specimens have been fabricated and tested under typical drop test conditions.

2.2 TEST PROGRAM

The description of the tests and the results are shown in Appendix A.

2.3 EVALUATION OF TEST RESULTS

2.3.1 End Caps - As shown in Table A-1, the core of 1.2 pcf provides a deceleration at a level less than 40g's as required.

2.3.2 Energy Absorption Cylinder - As shown in Table A-2, the core of 1.2 pcf still provides a deceleration at a level about three to five g's higher than the 27g's required. However, the test results show agreement with the theoretical values. As noted in Appendix B of Progress Report #2, a modification to reduce the core envelope or to change its configuration will be employed, if necessary, after the completion of the first phase.

3. CALIBRATION OF TEST EQUIPMENT

3.1 The hydrostatic pressure test tank was calibrated on March 19, 1964. An Ashcroft pressure gauge guaranteed accurate to plus or minus one per cent of the scale range of 0 to 60 p.s.i. was installed on the tank to measure air pressure. A letter of certification was received with the gauge.

3.2 The Differential Amplifier and Time Base of the Oscilloscope were calibrated on March 26, 1964, prior to drop testing. The calibration includes the following:

3.2.1 The gain adjustment to compensate for the difference in cathode-ray tube deflection sensitivities.

3.2.2 D.C. balance adjustment to eliminate possible error due to drift.

4. PRELIMINARY HYDROSTATIC TESTING

4.1 PURPOSE

The first hydrostatic pressure cylinder to be manufactured was rejected because of a wrinkle which occurred in the outer skin during fabrication. It was then decided to test it under hydrostatic pressure to assure the ability of the cylinder to withstand the hydrostatic pressure.

4.2 TEST PROGRAM

The description of the tests and the results are contained in Appendix B.

4.3 EVALUATION OF TEST RESULTS

The test specimen is shown in Figure B-1 of Appendix B. As is shown in the figure, the cylinder has the same basic configuration as the prototype hydrostatic cylinder except that the length is approximately 6.6 inches shorter than the prototype. However, the prototype is reinforced by a rigid threaded ring approximately nine inches from one end. Thus, the test specimen is about two inches longer than the effective length (for buckling purposes) of the prototype so that the test specimen should buckle at a slightly lower pressure than the prototype. Since the test specimen did not buckle with a pressure of 45 p.s.i., the prototype hydrostatic cylinder is more than adequate to carry 22 p.s.i.

5. TEST PROCEDURES

5.1 The development tests were briefly described in Part C.2 of Appendix C, Progress Report #1. Detailed procedures, including check lists, have been prepared for each of these tests except the Salt Spray, Sand and Dust, and Fragmentation Tests. The completed procedures will be submitted to Picatinny Arsenal for comments by April 6, 1964. Procedures for the Fragmentation Test will be completed by Picatinny Arsenal. Procedures for the Salt Spray and Sand & Dust Tests will be completed by May 30, 1964.

6. DEVELOPMENT TESTING

6.1 TEST SPECIMEN - CASE HXL-1-477

Development tests outlined in Table 1 were conduced on Case HXL-1-477. Details of construction are shown in Figures C1 through C3 of Appendix C. Figure C1 shows the basic dimensions, core and skin materials, core configuration, and skin gauges. Figure C2 shows the joint details and the potting materials. Figure C3 shows the dummy payload installed in the Case and the details of sealing the upper lid. All tests were conducted with the dummy payload installed in the Case.

A complete history of Case HXL-1-477 is on file in the Advanced Structures Group of Hexcel Products Inc. This file includes all data on the fabrication of the Case (drawings and tooling sketches) and all data from the test program (completed check lists, photographs of the Case, dynamic test data sheets, etc.)

6.2 HYDROSTATIC PRESSURE TESTS

6.2.1 Testing - Case HXL-1-477 was tested to 12 p.s.i. twice. The pressure was increased gradually from 0 to 12 p.s.i., held at 12 p.s.i. for five minutes each time, and then decreased to zero. No sign of buckling was observed on the Case; however, approximately 31 lbs. of water leaked into the energy absorption cylinder and the rear end cap. (The weight of water absorbed by the front end cap was not determined.) Details of the test are given in Part C-1 of Appendix C.

6. Development Testing (continued)

6.2.2 Evaluation of Test Results - Since there was no structural damage at 12 p.s.i., the basic problem is leakage. Almost all of the water which leaked into the Case was in the energy absorption core. There was only a very small amount of water inside the hydrostatic cylinder, and it is probable that all or most of this entered while the front end cap was being removed after the test. There was also an indication of a slight leak in the joint between the payload support ring and the hydrostatic cylinder. The main source of the leakage appeared to be through the porous potting compound used to seal the edges of the front and rear end caps and the slits in the skin of the outer cylinder. Necessary design modifications to correct this leakage will be incorporated in Case HXL-2-477 and will be reported in Progress Report #4, covering activities during the month of April, 1964.

6.3 DROP TESTS

6.3.1 Test Program - Case HXL-1-477 was drop tested from a height of 36 inches in the following sequence of drops:

6.3.1.1 End drop on rear end (fixed cap)

6.3.1.2 Flat drop on side.

6.3.1.3 Flat drop on side at position 180° from 6.3.1.2.

6.3.1.4 End drop on front end (removable cap).

6.3.2 Details of the testing and results obtained are shown in Part C-2 of Appendix C.

6. Development Testing (continued)

6.3.3 Evaluation of Test Results

6.3.3.1 End Drop (Fixed End Cap) - When the Case was dropped, a maximum of 72g's and an average of 34.2g's was obtained. The latter value is very close to the predicted value of 32g's (Page B-9, Progress Report #2). However, the value of 72g's is too high to conform to the required limit of 40g's. To prevent the core from damage through handling, the edges of the end caps were potted with a layer of light-weight potting approximately 0.2" thick and finished with a layer of light-weight adhesive. After the adhesive was cured, this 0.2" thick layer formed a ring-shaped reinforcement with a compressive strength much higher than the crushing strength of the core. Therefore, a high peak level was obtained at the instant of impact. After the potting compound was crushed, the g level dropped to 34g's as the core started to absorb the energy. This explanation was proven by the supplementary tests described in Paragraph C.2.1.2 of Appendix C.

6.3.3.2 Flat Drop - For the first flat drop, the maximum deceleration was 67.1g's which was followed by an average deceleration of 36g's. For the second flat drop, the

6. Development Testing (continued)

maximum deceleration was 68.5g's followed by an average deceleration of 36g's. These average values of deceleration are quite close to the values predicted (See Page B-6, Appendix B, Progress Report No. 2). However, they are still higher than the required value of 27g's.

The maximum deceleration of 67g's was obtained for the following reasons: (1) As the case was dropped flatwise, the skins of the front end cap, which were bonded to the core, experienced an edgewise compression loading. A much higher load was needed to buckle the skin than to crush the core of the energy absorption cylinder. Hence a higher g level was obtained. (2) To prevent the skin of the energy absorption cylinder from contributing rigidity to the energy absorbing property of the core, the skin was slotted into eight strips. However, these strips were too wide so that they had little effect in reducing the rigidity of the skin. (3) At the ends of the composite cylinder, the exposed core was coated with the same potting compound used to seal the end caps. When the cylinder was dropped flatwise, this layer of potting was in edgewise compression. For the same reason described above a higher g level was obtained.

6.3.3.3 Conclusions

The basic design concept appears to be valid. The high peak g levels appeared to be caused by the potting compound in the end caps and

6. Development Testing (continued)

cylinder and by the skin on the faces of the end caps. Necessary design modifications to correct these conditions will be incorporated in Case HXL-2-477 and will be reported in Progress Report #4 covering activities in April 1964.

7. MATERIAL PROCUREMENT

7.1 The following has been purchased for fabrication of the second prototype Case (Case No. HXL-2-477).

7.1.1	Core	Aluminum Flex Core 5052-.0013 x .470"Thick.
		AL-3/8-3003-.0007P x 2.8"Thick
		AL-3/16-5052-.001P x .470"Thick
7.1.2	Adhesive:	AF-111 Type A per MIL-A-25463 and MIL-A-5090D.

8. TOOLING DESIGN AND FABRICATION

8.1 The basic tools described in Paragraphs 6.1 and 6.2 of Progress Report #2 have been fabricated.

TABLE 1 - REVISED TEST PLAN
(Revision No. 2)

	CASE NO.	HYDROSTATIC PRESSURE 12psi	HYDROSTATIC PRESSURE 22psi	FLAT DROP	END DROP	EDGE DROP	TEMP. SHOCK	TEMP.& HUMIDITY	VIBRATION	ALTITUDE	HOIST STACK	FRAGMENTATION	SALT SPRAY	SAND DUST
PHASE I	HXL-1-477	1		2	3	4								
	HXL-2-477	1	5	4	2	3								
	HXL-3-477	1	7	5	6		2	3	4			8*		
	HXL-4-477	1		2#		3#	6		4#	5				
	HXL-5-477	1	7*	2#,6*				5	3#	4		8*		
PHASE II	HXL-6-477	1	8	7+	6			5	4	3	2#			
	HXL-7-477	1		3#		2#								
	HXL-8-477	1	5**	2,3+	4									
	HXL-9-477	1			2		3		4					
	HXL-10-477	1		5#		6#		3	4#	2				
	HXL-11-477	1	7* **	6*			4*	3*	2*		5#*	8*		
	HXL-12-477	1		2	3	4								
	Specimen 1	Will consist of a case section & samples of hardware (handles, hasps, latches, etc.)											1	
	Specimen 2	Will consist of a case section fully representative of complete assembly.												1

* to be conducted at Picatinny Arsenal ; # with saddles on; ** tests conducted to destruction; + cross drop.

NOTES: 1. This is a revised test plan. Additional changes will be made to emphasize a particular phase of test in which the previous units did not give a satisfactory result.
2. For some units, the hydrostatic test is conducted twice. The objective is to see if the drop test, temperature shock, etc., have any effect on the water tightness of the case.
3. Ozone test will be performed on samples of O=rings, gaskets, electrical connectors, and any exposed rubber or plastic parts.

A P P E N D I X A

TESTS OF TYPICAL CONSTRUCTION

APPENDIX A

TESTS OF TYPICAL CONSTRUCTION

A.1 TEST SPECIMENS

Two types of specimens were fabricated to simulate the different components of the energy absorption envelope: "flat" specimens, i.e., with the constant loaded cross-sectional area simulating the end caps; and "curved" specimens, i.e., with a varying loaded cross-sectional area simulating the energy absorption cylinder.

A.2 TYPICAL DROP TEST CONDITIONS

The drop test conditions were similar to the actual drop conditions, i.e., a drop height of 36 inches, and a drop weight of 0.8 pounds per square inch for the end caps and of 5.53 pounds per lineal inch for the energy absorption cylinder.

A.3 SPECIMEN MATERIALS

Core: AL-3/8-3003-.0007-1.2

Skin: AL-2024-T3-.012"T

Adhesive: AF-111

A.4 TEST RESULTS

Test results are given in Table A-1 (constant loaded area) and Table A-2 (varying loaded area).

TABLE A-1 DROP TEST FOR SPECIMENS WITH CONSTANT LOADED AREA

Type of Specimen: Flat, with constant loaded area
Compressive Strength: 31.6 p.s.i.
Crushing Strength: 21.1 p.s.i.
Drop weight: 12.8 lbs.
Drop height; 36 inches

SPECIMEN NO. (1)	SPECIMEN DIMENSION L x W x T (in.)	NUMBER OF DROPS	DECELERATION (g)				DURATION OF PEAK DECELERATION (milliseconds)
			TESTING			THEORETICAL	
			PEAK(2)	HIGH(2)	MEAN(2)		
1(1)	4 x 4 x 2.72	2	54.8(3)	27.4, 27.4	22, 24	41 for 1st drop 27.2 for 2nd drop	10
4	4 x 4 x 2.46	2	41(3), 41(4)	34.2, 34	30.8, 29	26.4	1, 1
5	4 x 4 x 2.5	1	43	33	27.4	26.4	1
6	4 x 4 x 2.48	2	- -	32.8, 32.8	27.4, 24	26.4	-
7	4 x 4 x 2.5	1	- -	34.2 -	27.4	26.4	-
8	4 x 4 x 2.48	3(5)	37(3), 34.2(4)	26, 27.4	24, 24	26.4	1.5, 1
9	4 x 4 x 2.5	1	-	37	27.4	27.2	-
10	4 x 4 x 2.5	2	- -	35	27.4	26.4	-

NOTE: (1) All cores were precrushed, except for Specimen No. 1.
(2) See explanation of peak, high, and mean in Fig. A-1
(3) Data for first drop.
(4) Data for second drop.
(5) Core was bottomed out at third drop so no data was recorded for third drop.

TABLE A-2 DROP TEST FOR SPECIMENS WITH VARYING LOADED AREA

Type of Specimen: curved, r_i = 6.75" with varying loaded area.
Crushing Strength: 21.1 p.s.i.
Drop weight: 16.6 lbs.
Drop Height: 36 inches

SPECIMEN NO.	SPECIMEN DIMENSION S x W x T(1) (in.)	NUMBER OF DROPS	DECELERATION (g)				DURATION OF PEAK DECELERATION (milliseconds)
			TESTING			THEORETICAL	
			PEAK	HIGH	MEAN		
13	8.2 x 3 x 2.4	1	-	34.2	27.4	32	-
14	8.2 x 3 x 2.4	1	-	34.2	27.4	32	-
15	8.3 x 3 x 2.38	2	-, 41.1	34.2, 28.8	27.4, 26	32, -	- , 1.5
16	8.25 x 3 x 2.42	1	-	34	27.4	32	-
17	8.1 x 3 x 2.5	1	32	27.4	25	32	-

NOTE: (1) S = length of outside arc
W = width
T = thickness

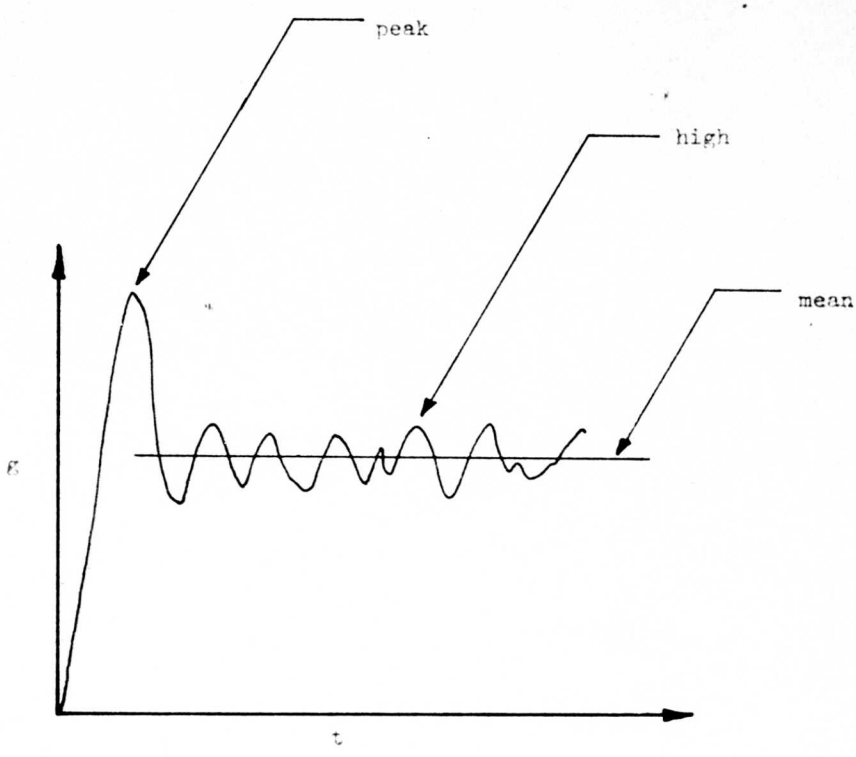


FIGURE A-1

A P P E N D I X B

PRELIMINARY HYDROSTATIC TESTS

APPENDIX B

PRELIMINARY HYDROSTATIC TESTS

B.1 TEST SPECIMEN

The test specimen is shown in Figure B-1. The skin and core are the same as on the prototype hydrostatic cylinder. The ends of the test specimen are covered with wooden caps which were sealed to the test specimen as shown in Figure B-1. A long outward wrinkle extending the length of the cylinder occurred during fabrication. This wrinkle occurred in the outer skin only and at the same location as the joint in the inner skin (the inner and outer skin joints were about 90° apart).

B.2 TEST RESULTS

The test specimen was placed in the hydrostatic pressure test tank, and the tank was filled with water. The specimen was weighted in the tank so that the water level was approximately level with the top of the specimen. Test No. 1 was conducted on March 19, 1964. Pressurization details are given in Table B-1. At 28 p.s.i., the pressure dropped suddenly to 22 p.s.i. where it stabilized. The pressure was allowed to remain at 22 p.s.i. for 0.68 minutes. The pressure was then released manually, and the specimen was removed from the tank and examined. There was no indication of buckling. There was no water inside the inner cylinder but some water did get into the core. There were several places on the side seam and the top and bottom seals that appeared to have

Preliminary Hydrostatic Tests (continued)

developed a leak. The side seam and the top and bottom seals were then resealed with zinc chromate sealer.

The specimen was again placed in the hydrostatic pressure test tank, and the tank was again filled with water to the same level as before.

Test No. 2 was conducted on March 19, 1964. Pressurization details are given in Table B-1. The pressure was increased to 45 p.s.i. with no drop. The pressure was held at 45 p.s.i. for six minutes and then released manually. During this six minute period, there was a slight decrease of about 0.2 p.s.i. This appeared to be caused by a leak between the head and body of the pressure test tank at the gasket, indicated by a slight bubbling. The specimen was examined and no sign of buckling was found.

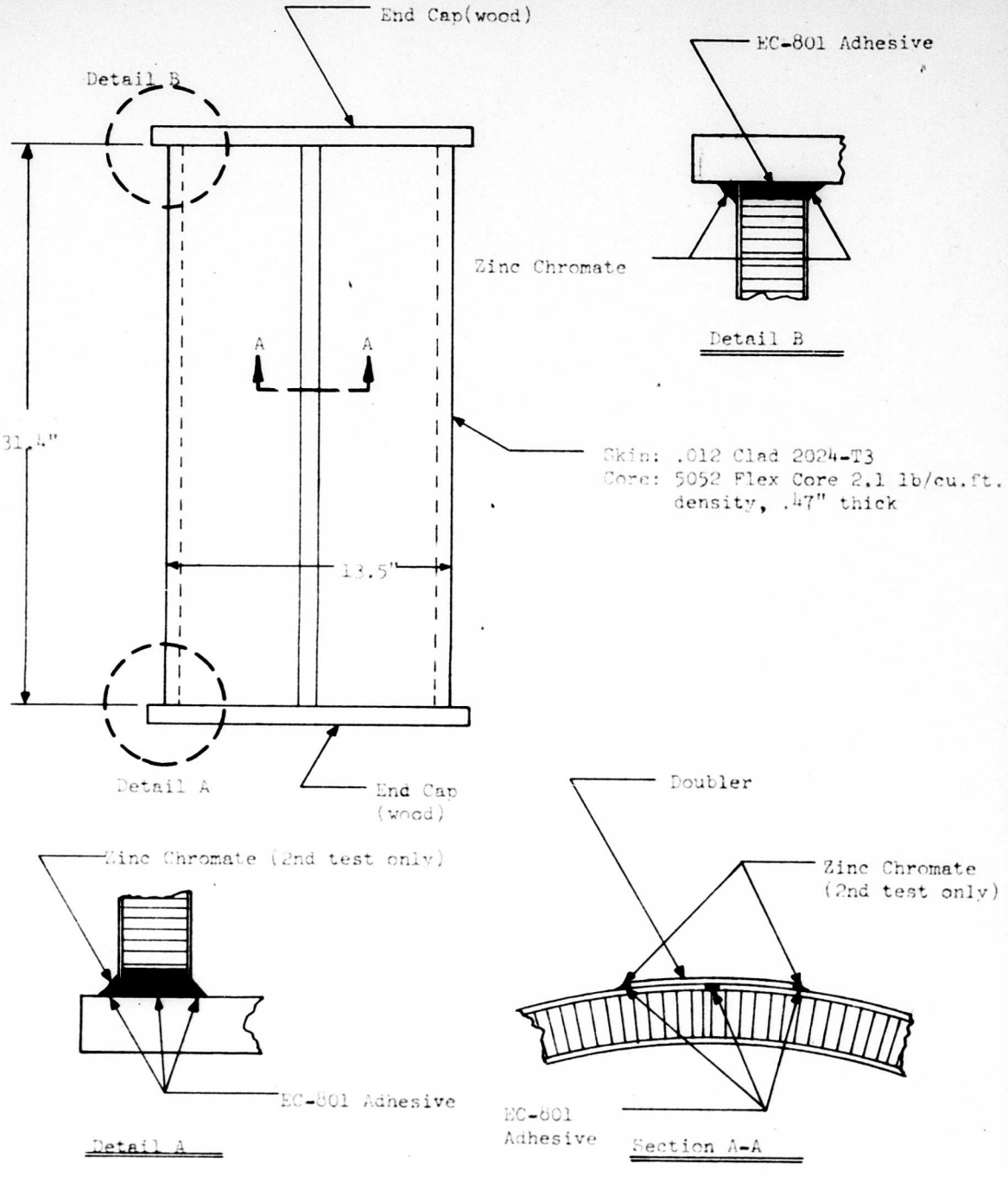
TABLE B-1 PRELIMINARY HYDROSTATIC TEST

PRESSURE (psi)	TIME (minutes) Test #1	Test #2
0	0	0
1	0.18	0.03
2	0.23	0.12
3	0.35	0.17
4	0.58	0.32
5	0.77	0.60
6	1.07	0.77
7	1.23	0.95
8	1.45	1.20
9	1.70	1.33
10	1.87	1.42
11	2.08	1.53
12	2.28	1.68
13	2.47	1.77
14	2.77	1.87
15	2.93	1.98
16	3.10	2.07
17	3.28	2.18
18	3.45	2.27
19	3.65	2.35
20	3.75	2.42
21	3.95	2.50
22	4.08	2.62
23	4.20	2.75
24	4.40	2.87
25	4.58	2.95
26	4.73	3.03
27	4.85	3.12
28	4.98*	3.20
29		3.27
30		3.30
31		3.38
32		3.47
33		3.50
34		3.60
35		3.68
36		3.77
37		3.85
38		3.90
39		3.97
40		4.05
41		4.17
42		4.27
43		4.33
44		4.40
45		4.45**

*Pressure dropped suddenly to 22 p.s.i. where it stabilized. Pressure was held at 22 p.s.i. for 0.68 minutes and then test was stopped.

**Pressure was held at 45 p.s.i. for 6.0 minutes and then test was stopped.

REFERENCE: 6065 CONTRACT NO. DA-04-200-AMC-477(A)



Not to scale. FIGURE B-1

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A P P E N D I X C

DEVELOPMENT TESTS

APPENDIX C

DEVELOPMENT TESTS

C.1 HYDROSTATIC PRESSURE TEST ON CASE HXL-1-477

C.1.1 Test Results - The test was conducted on March 25, 1964. The Case was placed in the pressure test tnak, and the tank was filled with water to a level covering the top of the Case. The pressure was increased to 12 p.s.i., held for five minutes, and decreased to zero. The pressure was again increased to 12 p.s.i., held for five minutes, and decreased to zero. No pressure drop was observed during either pressurization cycle. The water was then drained from the tank and the Case removed and examined. Pressurization details are given in Table C-1.

No signs of buckling were evident. However, leakage was noted. The Case (minus the removable cover) was weighed before and after the test, and an increase of 31 pounds was observed. Almost all of this water was in the energy absorption core. There was very little water inside the hydrostatic cylinder. Part of this water came from the cavity in the lid while the lid was being removed after the test.

TABLE C-1 HYDROSTATIC PRESSURE TEST

PRESSURE (psi)	TIME (minutes) Cycle #1	Cycle #2
0	0	0
1	0.05	0.18
2	0.10	0.23
3	0.23	0.33
4	0.32	0.43
5	0.45	0.65
6	0.60	0.95
7	0.78	1.17
8	1.00	1.42
9	1.22	1.72
10	1.40	1.83
11	1.50	2.03
12	1.63*	2.18*

*Pressure was held at 12 p.s.i. for five minutes and then reduced to zero.

C.2 DROP TESTS ON CASE HXL-1-477

During the hydrostatic pressure test, the end caps and the energy absorption cylinder core filled with water. Most of this water was drained out, but about three pounds remained at the start of the drop testing. The results of the drop testing are summarized in Table C-3.

C.2.1 End Drop on Rear End (Fixed End Cap)

C.2.1.1 Deformation - The end cap deformed in a manner shown in the sketch below because the payload was not supported by the cap but by a support ring in the hydrostatic cylinder. Thus, most of the load was transmitted to the energy absorption core by the ring-shaped area around the edge of the cap.

C.2.1.2 Supplementary Testing - Five different sizes of specimens were cut from the removable end cap where the core and potting were not crushed during the end drop test on the front end. These specimens were then drop tested. From the test results in Table C-2, it is seen that the deceleration provided by the core with the potting compound has a g level higher than the core without the potting compound.. It is noted that the potting was already partially buckled; hence an even higher g level should be expected during the drop while the potting functioned as a ring.

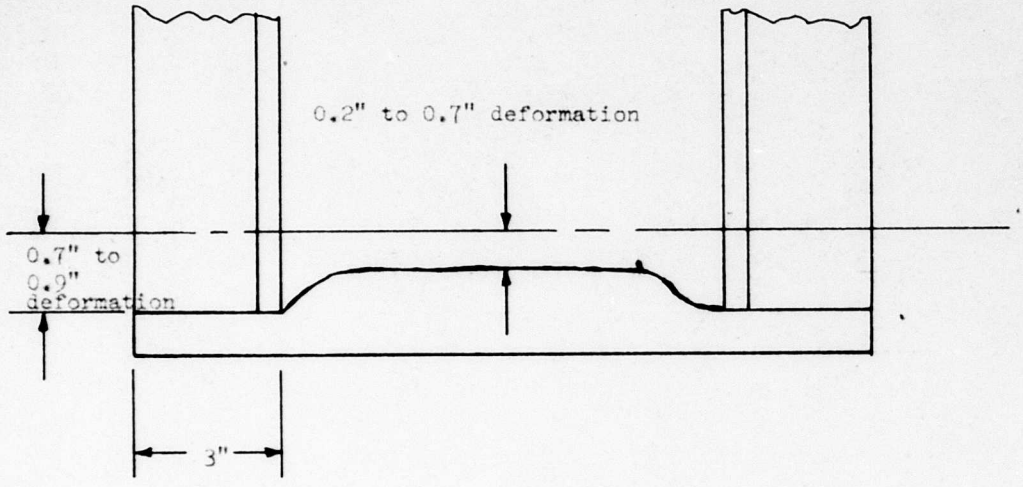

0.2" to 0.7" deformation
0.7" to
0.2"
deformation
3"

TABLE C-2 SUPPLEMENTARY TESTING

Drop Weight: 12.8 lbs.

Drop Height: 12 inches

Specimen Number	Specimen Size	DECELERATION (g) TESTING			
		*Theoretical	1st Drop	2nd Drop	3rd Drop***
1	3.2x2.2x1.3	11.5	24**	19.2**	13.7*
2	3x2.5x1.4	11.5	24**	21.2**	-
3	3.3x3x1.2	15.2	29.5**	33**	13.7*
4	3.2x2.5x1.9	13.1	13.7*	13.9*	-

* Without potting compound

** With potting compound

*** Core bottomed out after the test.

C.2.2 Flat Drop- After the drop test on the rear end, the fixed end cap was removed from the case. Two flat drops were then made at positions 180° apart. After the first flat drop, the skin on the top face of the removable front end cap was taken off.

C.2.2.1 Deformation - The deformation varied from 0.35" with width of about 9 inches at the front end (adjacent to the removable end cap) to 1.0 inches with a width of about 12 inches (adjacent to the rear end where there was no end cap). The same deformations were obtained for the second flat drop.

C.2.3 End Drop on Front End (Removable End Cap) - This test was not successful because the transducer cable was accidently cut during the drop. Thus, no g level was recorded.

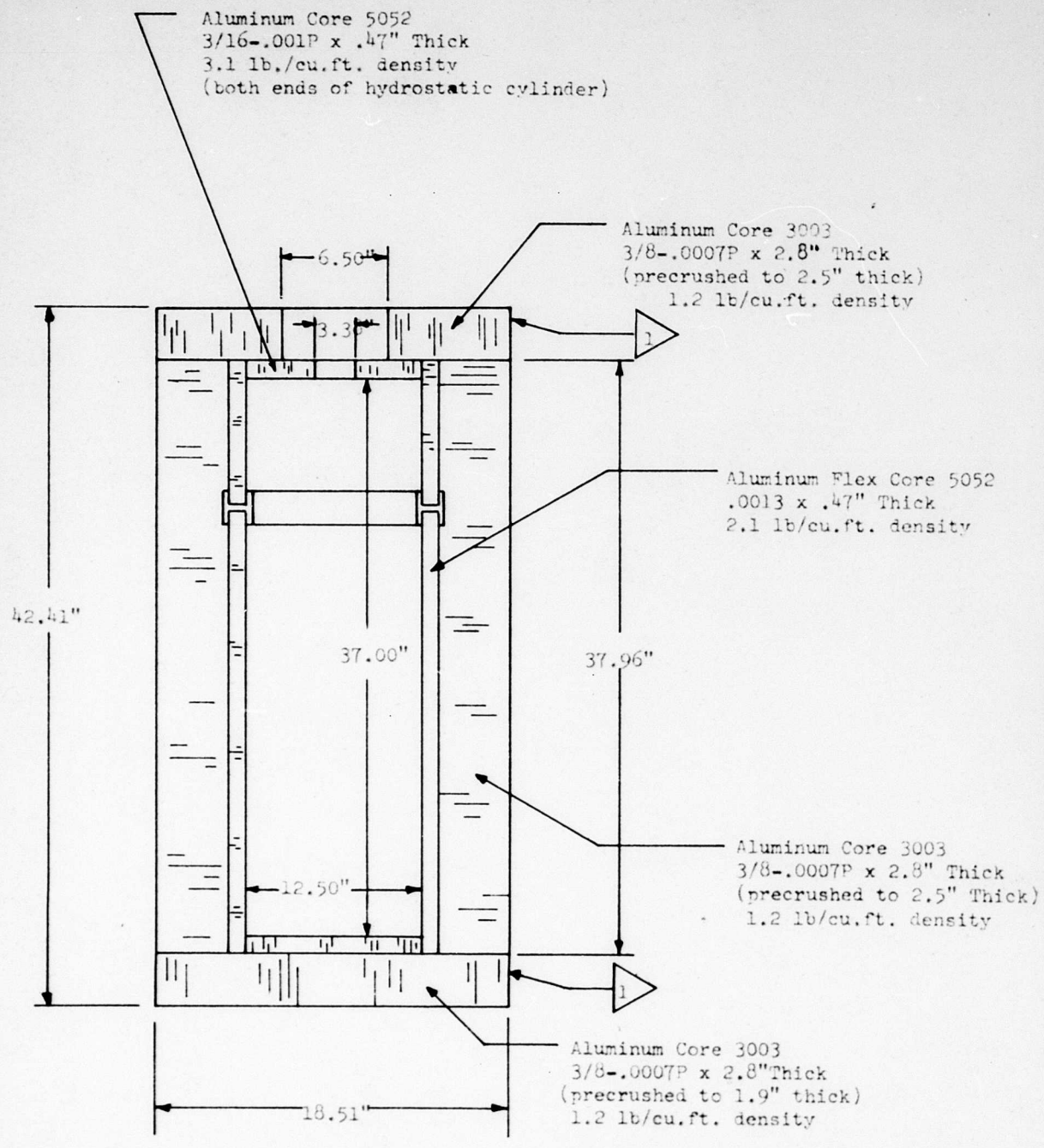
TABLE C-3 SUMMARY OF DROP TESTS

Case Weight: 208.5 lbs.
Drop Height: 36 inches

Drop No.	Type of Drop	Deceleration (g) Testing Maximum	Testing Average	Theoretical	Deformation (in.)	Remarks
1	End	78	34.2	32	0.7" to 0.9" under the composite cylinder; 0.2" to 0.7" at center of cap.	See B.6-B.11 of Progress Report #2 for theoretical decelerations.
2	Flat	67.1	36	30 - 35	0.35" with width of 9" at front end. 1.0" with width of 12" at rear end.	The crushed rear end cap was removed.
3	Flat	68.5	36	30 - 35	Same as Drop No.2	Drop position is 180° apart from No. 2.
4	End	-	-	30	-	The front (movable) end cap was already partially damaged due to flat drops. No decelerations were recorded because of accidental cutting of transducer cable during test.

REFERENCE: 6065

CONTRACT NO. DA-04-200-AMC-477(A)



NOTE: All skins .012"
Clad 2024-T3 aluminum.

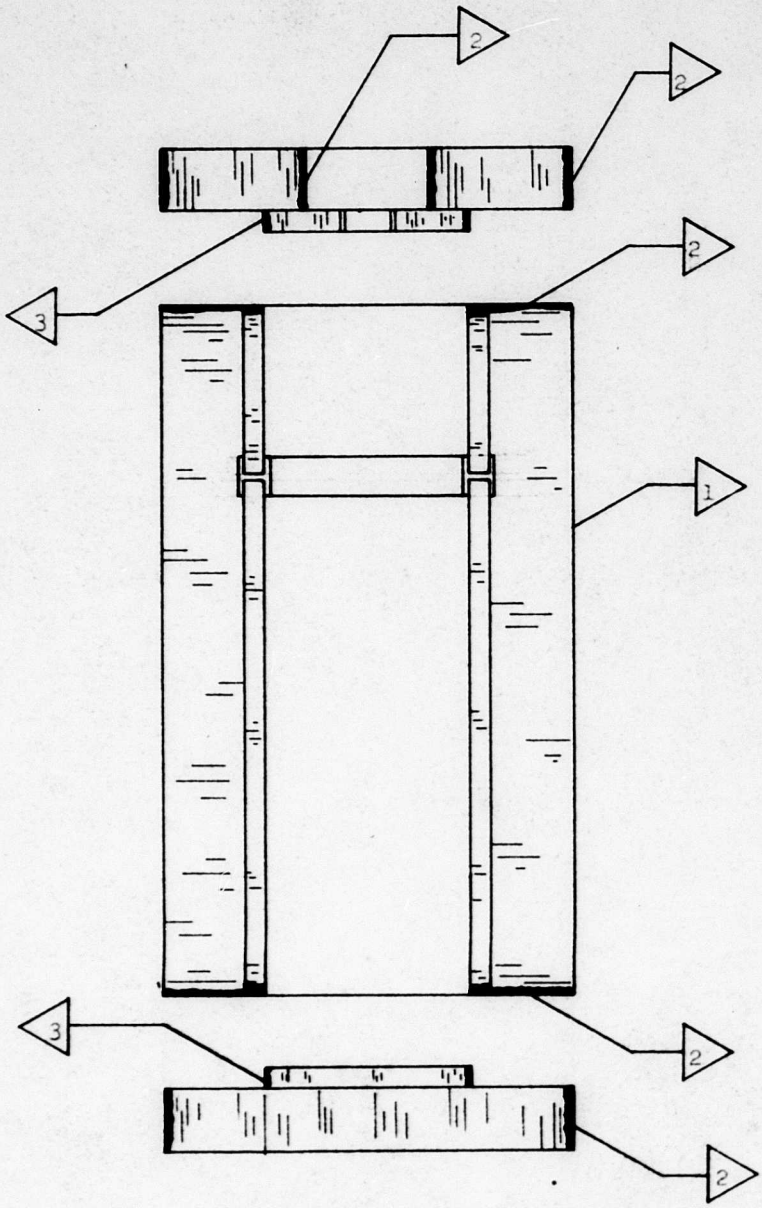
FIGURE C-1
(not to scale)

1 Caps have no skin around edges.

HEXCEL RESEARCH

BERKELEY, CALIFORNIA

REFERENCE: 6065 CONTRACT NO. DA-04-200-AMC-477(A)



1 Slits between skin segments filled with Phenolic Micro-balloons mixed with Epon 828; curing agent DTA.

2 Filler: Dylite Expandable Polystyrene Beads mixed with Epon 828; curing agent DTA.

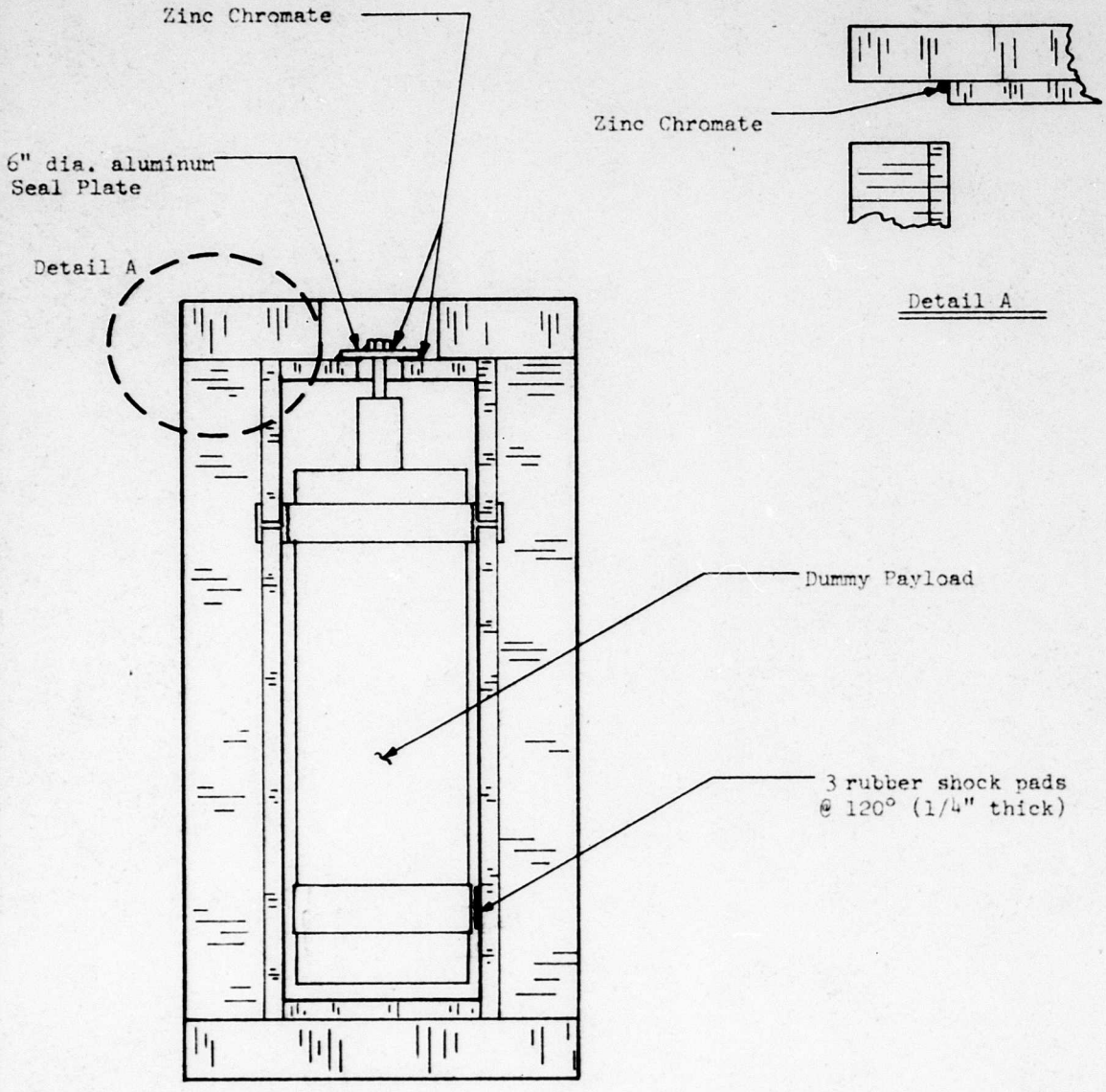
Outer coating: same as 1

3 Epon 828 mixed with Phenolic Micro-balloons

Not to scale FIGURE C-2

HEXCEL RESEARCH

BERKELEY, CALIFORNIA



Not to Scale

FIGURE C-3

HEXCEL RESEARCH

BERKELEY, CALIFORNIA

A P P E N D I X D

MAN HOURS EXPENDED

APPENDIX D

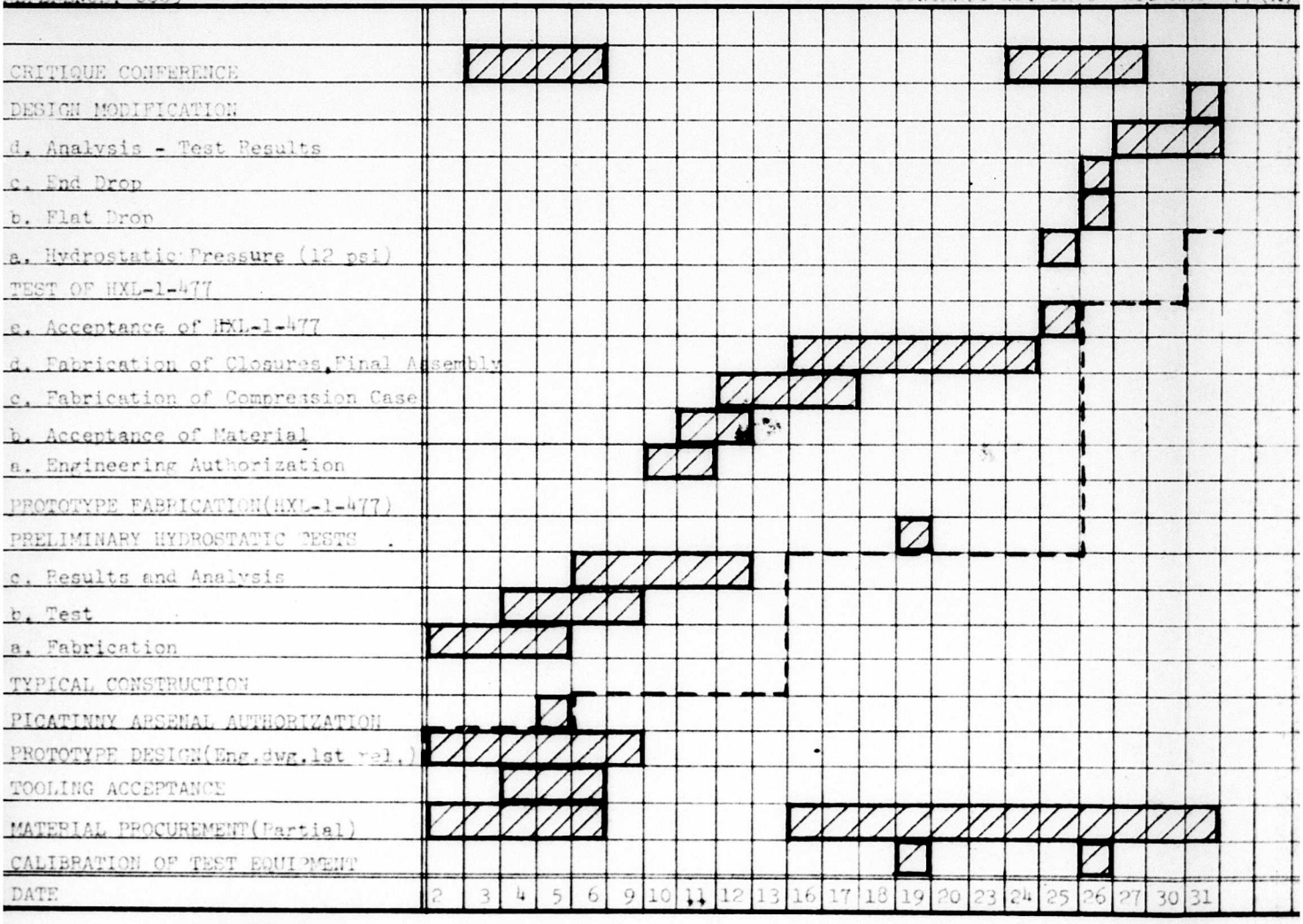
STATEMENT OF MAN HOURS EXPENDED - MARCH 1964

	MAN HOURS
ENGINEERING:	
Sr. Professional	84.0
Professional	464.0
DRAFTING:	
Technician	130.0
FABRICATION:	
Technician (Production Specimen)	39.5
OTHER:	
Clerical	47.0
TOTAL HOURS EXPENDED:	764.5

CHART III-1
CURRENT PROGRESS
MARCH 1964

HEXCEL RESEARCH
REFERENCE: 6065

April 7, 1964
CONTRACT NO. DA-04-200-AMC-477 (A)



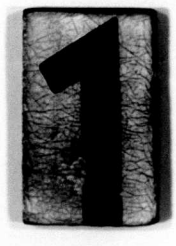


CHART III-1
CURRENT PROGRESS
MARCH 1964

April 7, 1964
CONTRACT NO. DA-04-200-AMC-477(A)

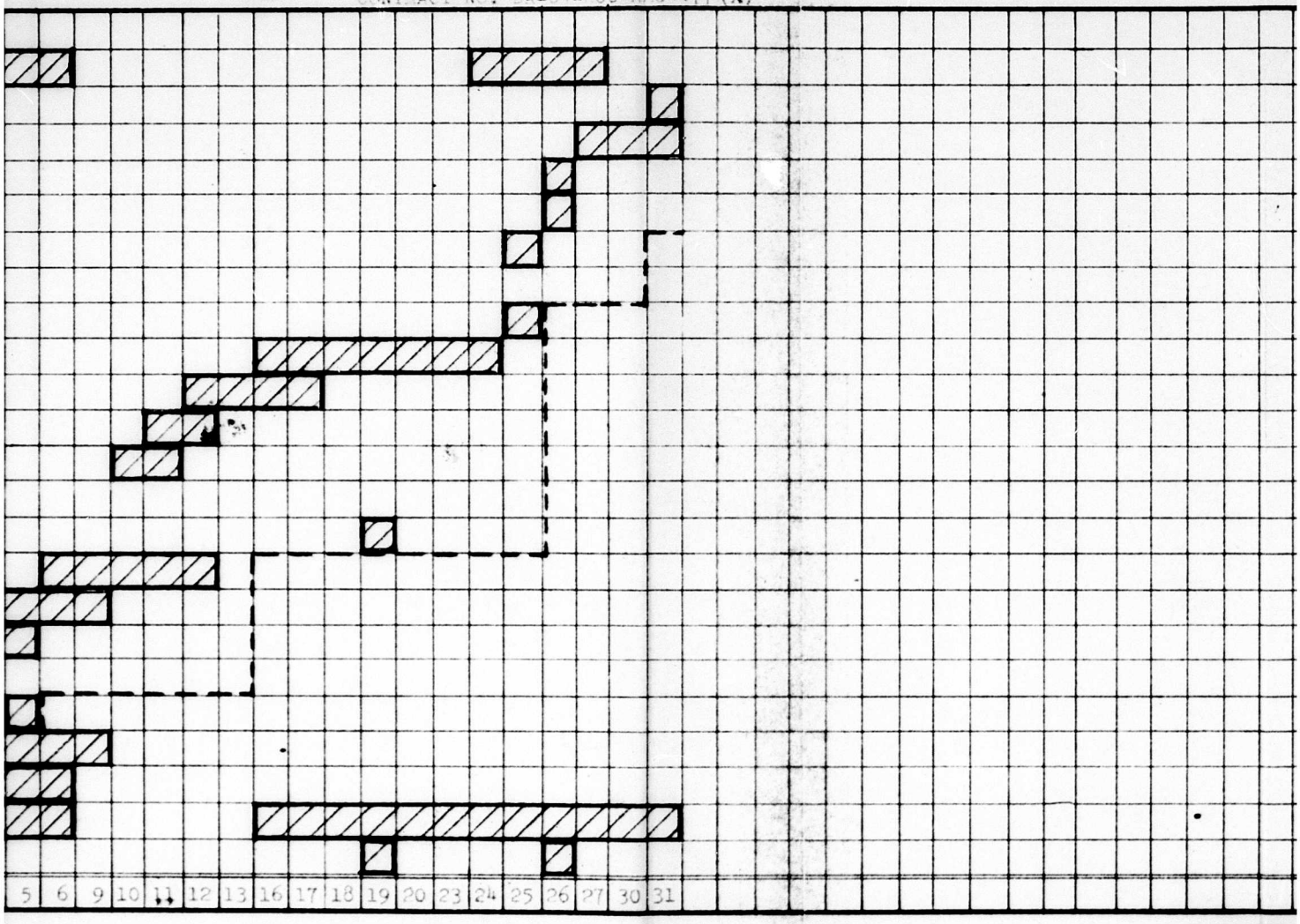
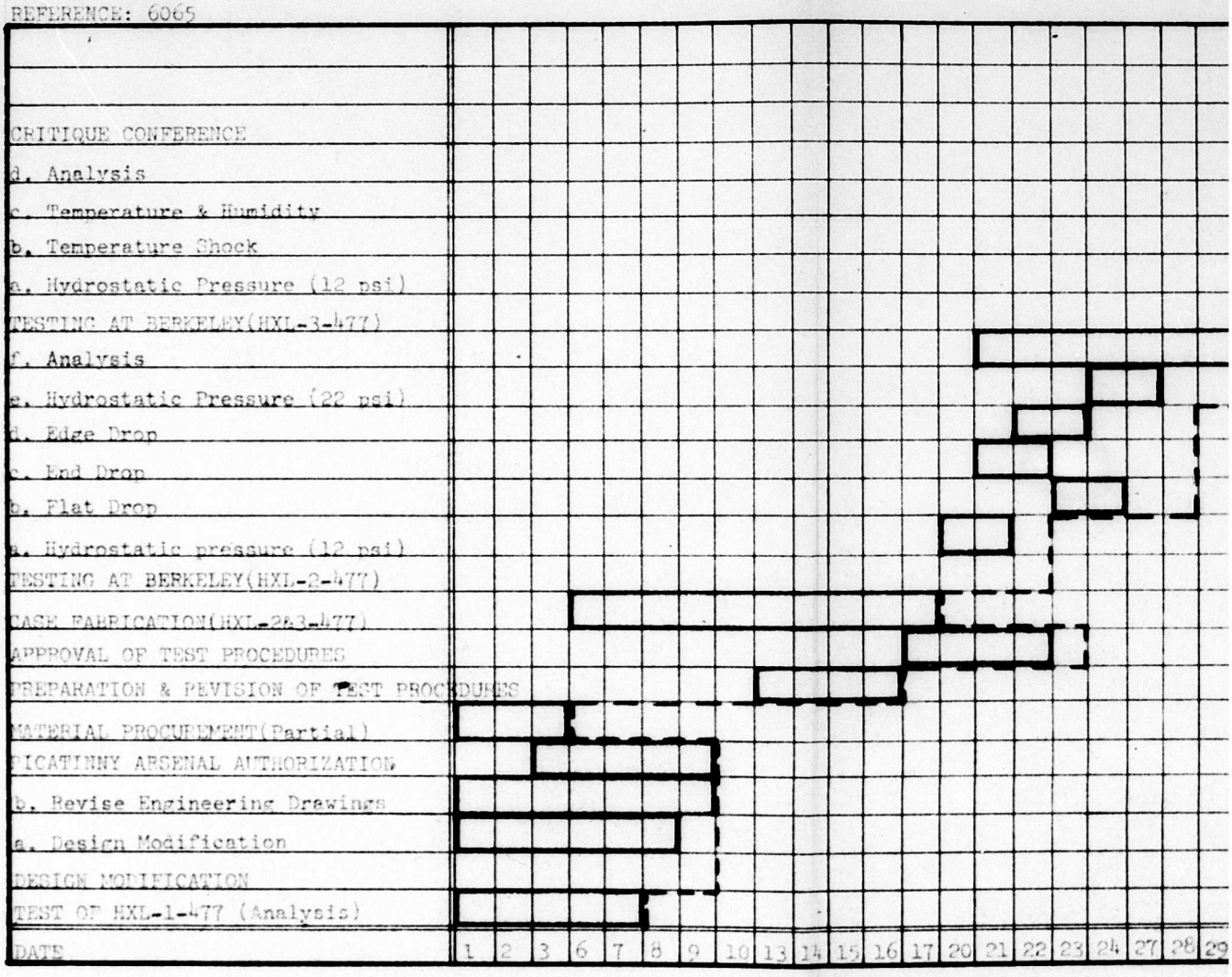


CHART III-2
PROGRAM OF ENSUING ACTIVITIES
APRIL AND MAY 1964

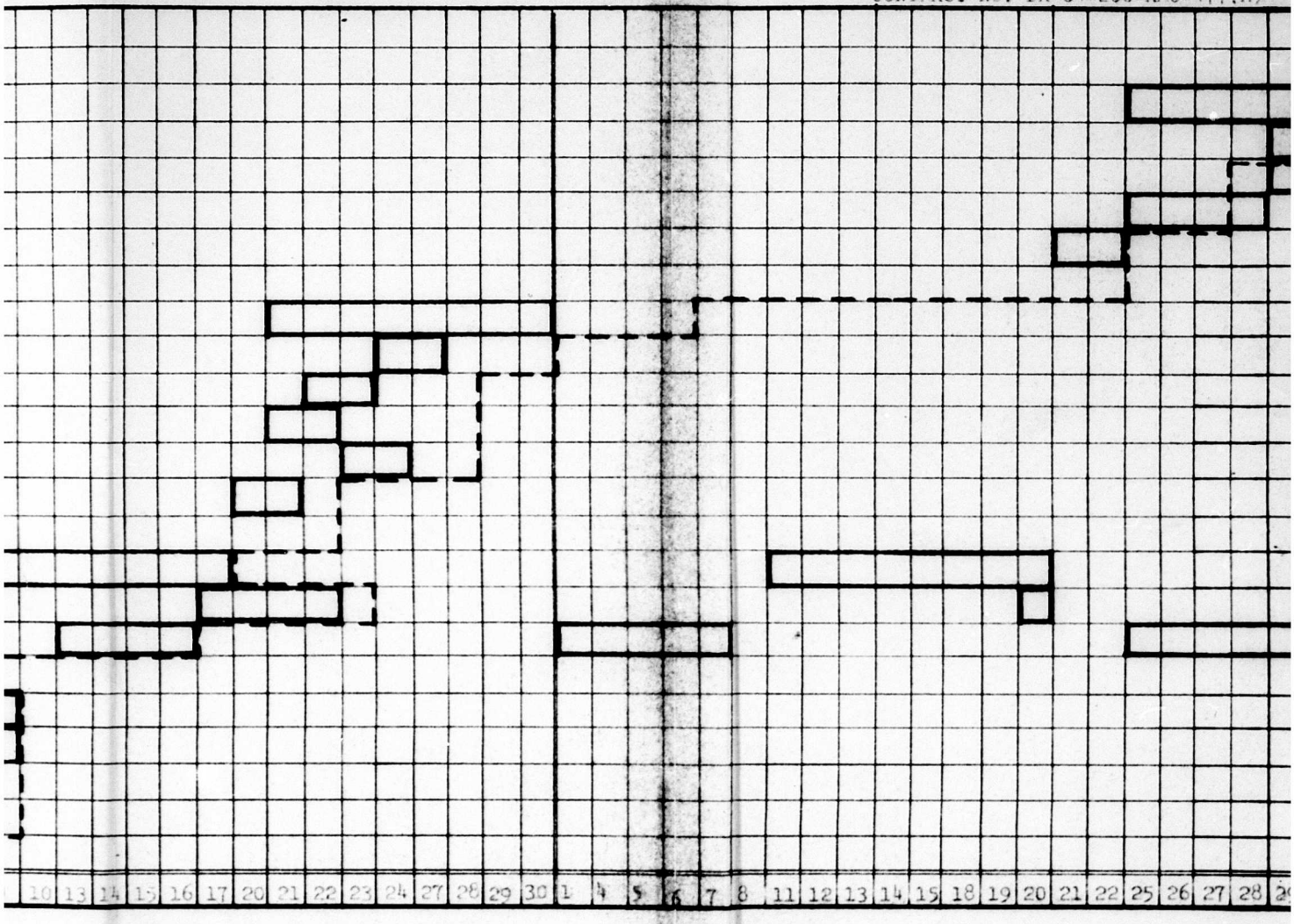
HEXCEL RESEARCH
REFERENCE: 6065



APRIL 1964

CHART III-2
PROGRAM OF ENSUING ACTIVITIES
APRIL AND MAY 1964

April 7, 1964
CONTRACT NO. DA-04-200-AMC-477(A)



APRIL 1964

MAY 1964

UNCLASSIFIED